Appendix G

Noise and Groundborne Vibration Calculations

ESA

Project: Santa Barbara County Broadband Project

Construction Noise Impact on Sensitive Receptors

Leq to L10 factor	3

				R1 at 25 feet from all pieces of equipment				
Construction Phase **Equipment Type**	**No. of Equip.**	**Reference Noise Level at 50ft, Lmax**	**Acoustical Usage Factor**	**Distance (ft)**	**Lmax**	**Leq**	**L10**	**Estimated Noise Shielding, dBA**
Demolition					***96***	***92***		
Tractor	1	84	40%	25	90	86	89	0
Tractor	1	84	40%	25	90	86	89	0
Dozer	1	85	40%	25	91	87	90	0
Tractor/Loader/Backhoe	1	80	40%	25	86	82	85	0
Drilling					***99***	***93***		
Drill Rig Truck	1	84	20%	25	90	83	86	0
Tractor/Loader/Backhoe	1	80	40%	25	86	82	85	0
Tractor/Loader/Backhoe	1	80	40%	25	86	82	85	0
Concrete Saw	1	90	20%	25	96	89	92	0
Tractor	1	84	40%	25	90	86	89	0
Excavator	1	85	40%	25	91	87	90	0
Trenching and Installation					***101***	***96***		
Dump Truck	1	84	40%	25	90	86	89	0
Dump Truck	1	84	40%	25	90	86	89	0
Tractor	1	84	40%	25	90	86	89	0
Tractor	1	84	40%	25	90	86	89	0
Excavator	1	85	40%	25	91	87	90	0
Dump Truck	1	84	40%	25	90	86	89	0
Tractor/Loader/Backhoe	1	80	40%	25	86	82	85	0
Drill Rig Truck	1	84	20%	25	90	83	86	0
Drill Rig Truck	1	84	20%	25	90	83	86	0
Concrete Saw	1	90	20%	25	96	89	92	0
Compressor (air)	1	80	40%	25	86	82	85	0
Site Preparation					***92***	***88***		
Dozer	1	85	40%	25	91	87	90	0
Tractor/Loader/Backhoe	1	80	40%	25	86	82	85	0
Paving					***96***	***91***		
Paver	1	85	50%	25	91	88	91	0
Pavement Scarafier	1	85	20%	25	91	84	87	0
Roller	1	85	20%	25	91	84	87	0
Maximum Combined Noise Levels						**96.1**		

Source for Ref. Noise Levels: LA CEQA Guides, 2006 & FHWA RCNM, 2005

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Table 1. CA/T equipment noise emissions and acoustical usage factors database.

CA/T Noise Emission Reference Levels and Usage Factors					
filename: EQUIPLST.xls					
revised: 7/26/05		Acoustical	Spec 721.560	Actual Measured	No. of Actual
	Impact	Use Factor	Lmax @ 50ft	Lmax @ 50ft	Data Samples
Equipment Description	Device ?	(%)	(dBA, slow)	(dBA, slow)	(Count)
				(samples averaged)	
Other Equipment	No	50%	85	-- N/A --	0
Auger Drill Rig	No	20%	85	84	36
Tractor/Loader/Backhoe	No	40%	80	78	372
Bar Bender	No	20%	80	-- N/A --	0
Blasting	Yes	#VALUE!	94	-- N/A --	0
Boring Jack Power Unit	No	50%	80	83	1
Chain Saw	No	20%	85	84	46
Clam Shovel (dropping)	Yes	20%	93	87	4
Compactor (ground)	No	20%	80	83	57
Compressor (air)	No	40%	80	78	18
Concrete Batch Plant	No	15%	83	-- N/A --	0
Concrete Mixer Truck	No	40%	85	79	40
Concrete Pump Truck	No	20%	82	81	30
Concrete Saw	No	20%	90	90	55
Crane	No	16%	85	81	405
Dozer	No	40%	85	82	55
Drill Rig Truck	No	20%	84	79	22
Drum Mixer	No	50%	80	80	1
Dump Truck	No	40%	84	76	31
Excavator	No	40%	85	81	170
Flat Bed Truck	No	40%	84	74	4
Forklift	No	10%	75		
Front End Loader	No	40%	80	79	96
Generator	No	50%	82	81	19
Generator (<25KVA, VMS signs)	No	50%	70	73	74
Gradall	No	40%	85	83	70
Grader	No	40%	85	-- N/A --	0
Grapple (on backhoe)	No	40%	85	87	1
Horizontal Boring Hydr. Jack	No	25%	80	82	6
Hydra Break Ram	Yes	10%	90	-- N/A --	0
Impact Pile Driver	Yes	20%	95	101	11
Jackhammer	Yes	20%	85	89	133
Man Lift	No	20%	85	75	23
Mounted Impact Hammer (hoe ram)	Yes	20%	90	90	212
Pavement Scarafier	No	20%	85	90	2
Paver	No	50%	85	77	9
Pickup Truck	No	40%	55	75	1
Pneumatic Tools	No	50%	85	85	90
Pumps	No	50%	77	81	17
Refrigerator Unit	No	100%	82	73	3
Rivit Buster/chipping gun	Yes	20%	85	79	19
Rock Drill	No	20%	85	81	3
Roller	No	20%	85	80	16
Sand Blasting (Single Nozzle)	No	20%	85	96	9
Scraper	No	40%	85	84	12
Shears (on backhoe)	No	40%	85	96	5
Slurry Plant	No	100%	78	78	1
Slurry Trenching Machine	No	50%	82	80	75
Soil Mix Drill Rig	No	50%	80	-- N/A --	0
Tractor	No	40%	84	-- N/A --	0
Vacuum Excavator (Vac-truck)	No	40%	85	85	149
Vacuum Street Sweeper	No	10%	80	82	19
Ventilation Fan	No	100%	85	79	13
Vibrating Hopper	No	50%	85	87	1
Vibratory Concrete Mixer	No	20%	80	80	1
Vibratory Pile Driver	No	20%	95	101	44
Warning Horn	No	5%	85	83	12
Welder	No	40%	73	74	5

Note that the criteria in Section 7.2, Step 4 do not apply to qualitative assessments.

Step 3: Use a Quantitative Construction Vibration Assessment

Use a quantitative construction vibration assessment to estimate vibration for appropriate projects per Section 7.2, Step 1b.

For quantitative construction vibration assessments, follow the recommended procedure in this step. Vibration source levels from typical construction equipment and operations are provided below, and procedures on how to estimate construction vibration for damage and annoyance are provided in Steps 3a and 3b, respectively.

- **Vibration Source Levels from Construction Equipment** – Table 7-4 presents average source levels in terms of velocity for various types of construction equipment measured under a wide variety of construction activities. The approximate rms vibration velocity levels were calculated from the PPV limits using a crest factor of 4, representing a PPV-rms difference of 12 dB. Note that although the table gives one level for each piece of equipment, there is considerable variation in reported ground vibration levels from construction activities. The data in Table 7-4 provide a reasonable estimate for a wide range of soil conditions.[66][67][68][69]

Table 7-4 Vibration Source Levels for Construction Equipment

<table>
<tr><th colspan="2">Equipment</th><th>PPV at 25 ft, in/sec</th><th>Approximate Lv* at 25 ft</th></tr>
<tr><td rowspan="2">Pile Driver (impact)</td><td>upper range</td><td>1.518</td><td>112</td></tr>
<tr><td>typical</td><td>0.644</td><td>104</td></tr>
<tr><td rowspan="2">Pile Driver (sonic)</td><td>upper range</td><td>0.734</td><td>105</td></tr>
<tr><td>typical</td><td>0.17</td><td>93</td></tr>
<tr><td colspan="2">Clam shovel drop (slurry wall)</td><td>0.202</td><td>94</td></tr>
<tr><td rowspan="2">Hydromill (slurry wall)</td><td>in soil</td><td>0.008</td><td>66</td></tr>
<tr><td>in rock</td><td>0.017</td><td>75</td></tr>
<tr><td colspan="2">Vibratory Roller</td><td>0.21</td><td>94</td></tr>
<tr><td colspan="2">Hoe Ram</td><td>0.089</td><td>87</td></tr>
<tr><td colspan="2">Large bulldozer</td><td>0.089</td><td>87</td></tr>
<tr><td colspan="2">Caisson drilling</td><td>0.089</td><td>87</td></tr>
<tr><td colspan="2">Loaded trucks</td><td>0.076</td><td>86</td></tr>
<tr><td colspan="2">Jackhammer</td><td>0.035</td><td>79</td></tr>
<tr><td colspan="2">Small bulldozer</td><td>0.003</td><td>58</td></tr>
</table>

* RMS velocity in decibels, VdB re 1 micro-in/sec

3a. Damage Assessment

Assess for building damage for each piece of equipment individually.

Construction vibration is generally assessed in terms of peak particle velocity (PPV), as described in Section 5.1.

- Determine the vibration source level (PPV_{ref}) for each piece of equipment at a reference distance of 25 ft as described above and in Table 7-4.
- Use Eq. 7-2 to apply the propagation adjustment to the source reference level to account for the distance from the equipment to the receiver. Note that the equation is based on point sources with normal propagation conditions.

$$PPV_{equip} = PPV_{ref} \times (\frac{25}{D})^{1.5} \qquad \textbf{Eq. 7-2}$$

where:

PPV_{equip} = the peak particle velocity of the equipment adjusted for distance, in/sec
PPV_{ref} = the source reference vibration level at 25 ft, in/sec
D = distance from the equipment to the receiver, ft

3b. Annoyance Assessment
Assess for annoyance for each piece of equipment individually. Ground-borne vibration related to human annoyance is related to rms velocity levels, expressed in VdB as described in Section 5.1.

Estimate the vibration level (L_v) using Eq. 7-3.

$$L_{v.distance} = L_{vref} - 30log(\frac{D}{25}) \qquad \textbf{Eq. 7-3}$$

where:

$L_{v.distance}$ = the rms velocity level adjusted for distance, VdB
L_{vref} = the source reference vibration level at 25 ft, VdB
D = distance from the equipment to the receiver, ft

Step 4: Assess Construction Vibration Impact

Compare the predicted vibration levels from the Quantitative Construction Vibration Assessment with impact criteria to assess impact from construction vibration.

Assess potential damage effects from construction vibration for each piece of equipment individually. Note that equipment operating at the same time could increase vibration levels substantially, but predicting any increase could be difficult. The criteria presented in this section should be used during the environmental impact assessment phase to identify problem locations that must be addressed during the engineering phase.

Compare the PPV and approximate L_v for each piece of equipment determined in Section 7.2, Step 3 to the vibration damage criteria in Table 7-5, which is presented by building/structural category, to assess impact.(70)(71) The approximate rms vibration velocity levels were calculated from the PPV limits using a crest factor of 4.